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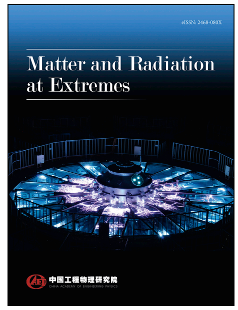

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Laser radiation pressure proton acceleration in gaseous target

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Abstract

An analytical model for hole boring proton acceleration by a circularly-polarized CO_2 laser pulse in a gas jet is developed. The plasma density profile near the density peak is taken to be rectangular, with inner region thickness l around a laser wavelength and density 10% above the critical, while the outside density is 10% below the critical. On the rear side, plasma density falls off rapidly to a small value. The laser suffers strong reflection from the central region and, at normalized amplitude $a_0 \geq 1$, creates a double layer. The space charge field of the double layer, moving with velocity $v_f \hat{\boldsymbol{z}}$, reflects up-stream protons to $2v_f$ velocity, incurring momentum loss at a rate comparable to radiation pressure. Reflection occurs for $v_f \leq \omega_p \sqrt{z_f lm / m_p}$, where m and m_p are the electron and proton masses, z_f is the distance travelled by the compressed electron layer and ω_p is the plasma frequency. For Gaussian temporal profile of the laser and parabolic density profile of the upstream plasma, the proton energy distribution is narrowly peaked.

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